

# IMPACT OF STAND MANAGEMENT PRACTICES ON BEETLE DIVERSITY

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**Abstract**—Insects are useful indicators of change within ecosystems because of their abundance, richness and functional importance. Stand management practices impact the insect community within a forest. Therefore, the objective of the project is to determine the impact of various stand management practices on the diversity of beetles within selected treatments. Four harvesting treatments and uncut controls were examined. The lowest number of beetle families captured was in the control plots. Diversity within individual families can also vary based upon management practices. For example, the same 6 species of Silphidae were captured in 4 of the 5 treatments but fewer individuals were captured in the control plots compared with the treatments. Similarly, the lowest number of Scarabaeidae captured (species and individuals) was in the uncut control plots. Therefore, disturbing stands through tree harvesting increased the overall diversity of beetle families as well as diversity within select families.

## INTRODUCTION

Insects and other arthropods are abundant throughout terrestrial ecosystems (May 1989, Wheeler 1990, Gaston 1991) where they play a role in most ecosystem processes and have a major impact on energy flow through a system (Samways 1994). Because of their abundance, species richness and functional importance, insects are useful indicators of ecosystem change (Rosenberg and others 1986). The ecosystem management project in the Ouachita Mountains is examining a variety of timber harvesting treatments and there were 13 stand management treatments implemented (Baker 1994). The objective of my work has been to examine the diversity and abundance of populations of beetles (Coleoptera) following the implementation of 5 of these treatments (unmanaged controls, single-tree selection cuts, group selection cuts, shelterwood cuts and clearcuts).

In the past, stand management research involving insects has primarily focused on species of economic importance, but stand management practices also impact other insect species found within a forest. Studies that examined environmental impacts and used insects as bioindicators range from examining all insect taxonomic groups (i.e. Stork 1991) to using a single insect family such as the beetle family Cicindelidae (Pearson and Cassola 1992). The choice of taxonomic group(s) to utilize for monitoring should be related to the system under examination and the potential impact of the applied treatments on the group(s). Therefore, species do not need to be rare to be useful as bioindicators of system change. In this study, I examined both the overall community of beetles present in the stands as well as 2 specific families (Silphidae and Scarabaeidae). In these stands, most of the individuals of these 2 families that were captured are carrion-feeding insects. In general, the carrion-feeding guild of insects is dependent upon the presence of small vertebrates in the system, which in turn is regulated in large part by the vegetation.

One reason for choosing to examine the carrion-feeding guild of insects is that there are known populations of the

endangered American burying beetle, *Nicrophorus americanus*, in western Arkansas and eastern Oklahoma. These populations appear to be remaining fairly stable and are located near where the ecosystem management project is occurring. In addition to American burying beetle, the community of carrion-feeding insects is a large and diverse group. This feeding guild can be sensitive to environmental changes that impact the carrion resource or that result in the introduction of new members to the guild (Summerlin and others 1984, Porter and Savignano 1990, Stoker and others 1995). The diversity and abundance of the guild, along with its sensitivity to environmental changes make it a good candidate group for examining treatment impact on biodiversity.

## METHODS

### Treatments

The beetle communities occurring within 20 stands (18 in Ouachita National Forest and 2 in Ozark National Forest) were examined. Each stand was approximately 40 acres in size and treatments were applied in 1993 (Mersmann and others 1994 for a more detailed description). Stands were randomly assigned to treatment categories. Four stands per treatment were examined. The treatments were: 1) unmanaged controls in which no harvesting and no other stand management practices occurred; 2) single-tree selection cuts in which some harvesting occurred but a residual basal area of from 45 – 65 ft<sup>2</sup> per acre was retained; 3) group selection cuts in which harvest openings ranged from 0.1 – 1.0 acres and the pine component outside of the openings was thinned to 70 – 80 ft<sup>2</sup> per acre but no hardwoods were harvested or removed from outside of the group openings; 4) shelterwood cuts were harvested while retaining from 20 – 40 of the largest trees per acre (approximately 30 – 40 ft<sup>2</sup> per acre of basal area); and 5) clearcuts in which all trees were harvested except 2 – 5 ft<sup>2</sup> per acre of hardwoods that were retained as den trees and mast producers. A more detailed description of the treatments can be found in Baker (1994).

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*Citation for proceedings:* Guldin, James M., tech. comp. 2004. Ouachita and Ozark Mountains symposium: ecosystem management research. Gen. Tech. Rep. SRS-74. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 321 p.

## Insect Trapping

The beetle communities present within the stands were examined using 4 types of traps. One malaise trap (7 foot tall) was placed in each of 15 stands (3 stands per treatment) for 3 consecutive days during May and June of 1998. These are unbaited traps that indiscriminately capture flying insects. Insects were removed at the end of the 3-day period. Carrion-baited pitfall traps (Lomolino and others 1995) were placed in 10 stands (2 stands per treatment) during May and June of 1998. An 8-trap transect was used and monitored daily for 3 consecutive days. Transects were placed near the center of each stand and traps were approximately 25 yards apart within the transects. Beetles were removed from the traps daily and the traps were rebaited as needed. A second transect of 8 pitfall traps baited with a combination of EtOH and turpentine were placed in the plots approximately 50 yards from the first transect. These traps were also examined daily for 3 consecutive days. These traps are designed to capture pine regeneration insects (Hunt and Raffa 1989). Lindgren funnel traps (45 inches long with a trap surface area of 538 in<sup>2</sup>) were placed in 10 stands (2 per treatment) during May of 1999. There were 2 traps placed in each stand, 1 trap was baited with EtOH and alpha-pinene and the other trap was baited with EtOH, alpha-pinene and frontalin, the aggregation pheromone of the southern pine beetle. These traps were left in place for 3 weeks. These traps capture a wide variety of beetles but the specific baits were chosen to sample for bark beetles and their associates.

## Analyses

All of the individual beetles captured in all of the traps were identified to family. The data from all trap types were combined to compare family richness among treatments. Prior sampling had occurred on several of these sites following application of the treatments in 1993 (Carlton and others 1994). The two sampling periods had 3 treatment types in common (uncut controls, group selection cuts and shelterwood cuts). For these 3 treatments, data on beetle families was compared between the sample dates for family richness and shared families.

The individual beetles of 2 families, Silphidae and Scarabaeidae, were identified to genus (and species where possible). Within each of the 2 families, comparisons of total number of beetles captured, species richness and species diversity were made among treatments. For these comparisons, species richness refers to the number of species captured and species diversity was calculated using the Shannon-Weaver diversity index (see Price 1975). The 3 most commonly captured species in each of these 2 families was determined and the number of individuals captured in the carrion-baited pitfall traps compared among treatments. The comparisons were based on the number of beetles captured per trap per night and only undisturbed traps were used in the comparison.

## RESULTS AND DISCUSSION

### Overall Family Diversity

There were a total of 47 families of beetles captured during the 1998 and 1999 sample periods (table 1). The lowest number of beetle families (n=30) was captured in the unman-aged control stands. The stands that received some har-

vesting treatment all had a larger number of beetle families present and the number of families captured was similar among stands (n=36 to 39). Therefore, some stand disturbance through harvesting appeared to increase the diversity of beetle families present in these stands.

A similar pattern can be distinguished in the 1993 data presented by Carlton and others (1994). They reported capturing a total of 54 families. Of the 3 treatments in common between the 1993 and 1998/99 samples their control plot also had the lowest number of families captured in 1993 (n=23) followed by the shelterwood cut (n=33) and the group selection cut (n=40).

It is interesting to note that while the sampling for these 2 studies occurred 5 to 6 years apart and different trapping schemes were used, there were 36 families of beetles captured in common between the 2 studies. Further, the lowest number of families was captured in the control stands during both studies. However, 29 families of beetles were unique to one or the other study. This may be largely due to the time difference between when trees were harvested and when beetle sampling occurred. This demonstrates the need to sample over a long period of time to establish patterns in diversity or the impact of disturbance events on insect populations.

### Diversity Within the Family Silphidae

Although there are known populations of American burying beetle in western Arkansas and eastern Oklahoma, none were captured on these sites during the 2 summers that sampling was conducted. One explanation is that the beetle seems to do best in areas that are undisturbed and have had little human activity (see Ratcliffe 1996). Also, the study plots are relatively small and the beetle may be present in the National Forest(s), just not in these study plots.

There were 6 species of Silphidae captured in 4 of the 5 treatment types (table 2). In the other treatment type, shelterwood cuts, 5 of the 6 species were captured. The lowest number of individual silphids captured was in the control stands, followed by the shelterwood cut stands, the clearcuts, the single-tree selection cut stands and the group selection cut stands. Although the measures of diversity were similar across treatment types, the lowest diversity ( $H' = 1.21$ ) occurred in the shelterwood cut stands. The measure of diversity was similar in the control stands ( $H' = 1.22$ ) and increased in the stands that had been clearcut ( $H' = 1.31$ ) or had been harvested as single-tree selection cuts ( $H' = 1.43$ ) or group selection cuts ( $H' = 1.45$ ). The 2 most abundant species of silphids captured were always the 2 species of *Oceoptoma*. These 2 species are the smallest of the silphids captured during this study and they are both very active during the spring (see Ratcliffe 1996).

As would be expected, different species demonstrated different responses to the harvesting disturbance. The capture distributions of the 3 most commonly caught silphids are presented in figure 1. For *Oceoptoma inaequale*, there was a slight increase in abundance with increasing harvest as long as some residual canopy remained. There was a pronounced decrease in capture of this beetle in the clearcut stands. In contrast, captures of *O. novaboracense* typically

**Table 1—Families of beetles captured within stands that had received 1 of the 5 harvesting treatments**

Family	Treatment				
	Control	Single tree	Group selection	Shelterwood	Clearcut
Rhysodidae	x	x	x	x	x
Carabidae	x	x	x	x	x
Hydrophilidae	x	x	x	x	x
Histeridae	x	x	x	x	x
Pselaphidae	x	x	x	x	x
Staphylinidae	x	x	x	x	x
Leiodidae	x	x	x	x	x
Silphidae	x	x	x	x	x
Eucinetidae		x		x	
Scarabaeidae	x	x	x	x	x
Byrrhidae		x			
Ptilodactylidae				x	
Buprestidae	x	x	x	x	x
Elateridae	x	x	x	x	x
Throscidae	x				
Eucnemidae		x	x	x	x
Phengodidae	x	x	x		x
Lampyridae		x			x
Cantharidae	x	x	x	x	x
Lycidae		x	x	x	x
Dermestidae	x	x	x	x	x
Anobiidae	x	x	x	x	x
Bostrichidae		x	x	x	
Lyctidae	x	x	x	x	x
Trogositidae	x	x	x	x	x
Cleridae	x	x	x	x	x
Melyridae		x		x	
Nitidulidae			x	x	x
Cucujidae			x	x	
Erotylidae		x	x	x	
Phalacridae				x	
Coccinellidae	x	x	x	x	x
Endomychidae					x
Lathridiidae			x	x	x
Colydiidae		x	x		x
Tenebrionidae	x	x	x	x	x
Oedemeridae	x	x	x	x	x
Melandryidae	x	x	x	x	x
Mordellidae	x	x	x	x	x
Pedilidae	x	x	x	x	x
Cerambycidae	x	x	x	x	x
Bruchidae		x	x	x	x
Chrysomelidae	x	x	x	x	x
Anthribidae	x				
Curculionidae	x	x	x	x	x
Platypodidae		x			
Scolytidae	x	x	x	x	x

**Table 2—Members of the family Silphidae captured within stands that had received 1 of the 5 harvesting treatments**

Species	Treatment				
	Control	Single tree	Group selection	Shelter-wood	Clear-cut
<i>Necrophila americana</i>	1	4	10	5	13
<i>Oiceoptoma inaequale</i>	19	57	53	46	31
<i>O. novaboracense</i>	23	28	63	23	53
<i>Nicrophorus orbicollis</i>	7	14	19	9	1
<i>N. pustulatus</i>	1	7	4	0	1
<i>N. tomentosus</i>	1	10	13	3	15
Total capture	52	120	162	86	114

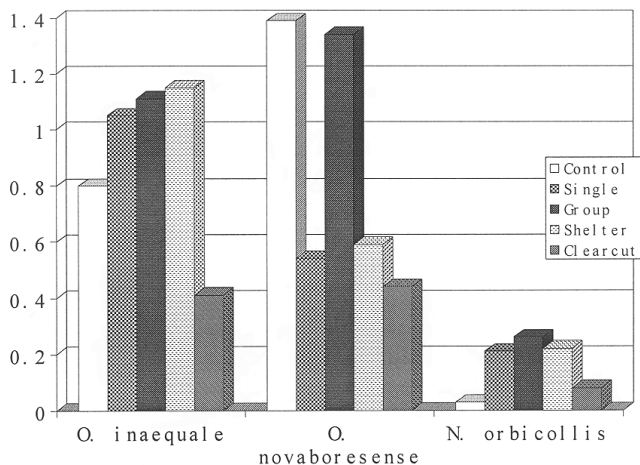


Figure 1—The number of *Oiceoptoma inaequale*, *O. novaboracense*, and *Nicrophorus orbicollis* captured per trap night in the pitfall traps that were baited with carrion. There were eight traps per stand and trapping was conducted over three consecutive nights.

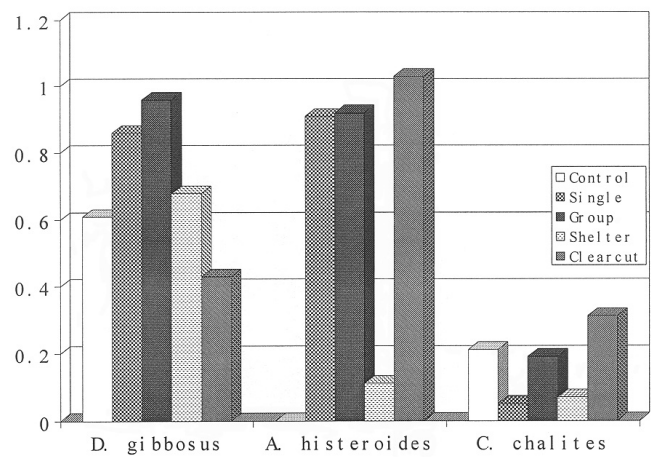


Figure 2—The number of *Deltochilum gibbosus*, *Ateuchus histeroides*, and *Canthon chalcites* captured per trap night in the pitfall traps that were baited with carrion. There were eight traps per stand and trapping was conducted over three consecutive nights.

decreased with increasing tree harvest. Trap catch for the third species, *Nicrophorus orbicollis*, initially increased but then declined as harvest intensity increased beyond the group selection cuts.

### Diversity Within the Family Scarabaeidae

There were 20 species of scarabs captured in the stands during the 2 years of this project (table 3). The lowest number of species ( $n=11$ ) and the fewest individuals ( $n=67$ ) were captured in the control stands. The largest number of species ( $n=15$ ) and the most individual scarabs ( $n=191$ ) were captured in the group selection stands. The measure of species diversity was lowest in the control stands ( $H'=1.72$ ) followed by the single-tree selection stands ( $H'=1.93$ ), the clearcut stands ( $H'=1.94$ ), the shelterwood cut stands ( $H'=2.04$ ) and the group selection cut stands ( $H'=2.16$ ).

The 3 most abundant species captured were *Deltochilum gibbosus*, *Ateuchus histeroides* and *Canthon chalcites*. The capture distributions for these 3 species are presented in figure 2. Captures of *D. gibbosus* initially increased with harvest disturbance in the single-tree selection and group selection stands but then decreased in the shelterwood cut and clearcut stands. No *A. histeroides* were captured in the control stands, but the species was present in all of the stands that had received some harvesting treatment. There was no discernable pattern in the distribution of *C. chalcites* captures. As with the silphids, there was a species-specific response by the beetles to harvest disturbance intensity.

### CONCLUSIONS

Overall, stand disturbance through tree harvesting increased the diversity of beetle families present in stands. For the individual families examined, species richness was similar among treatments for the Silphidae but the fewest number

**Table 3—Members of the family Scarabaeidae captured within stands that had received 1 of the 5 tree harvesting treatments**

Species	Treatment				
	Control	Single tree	Group selection	Shelter-wood	Clear-cut
<i>Aphodius</i> sp.	1	1	0	0	0
<i>Ateuchus histeroides</i>	0	40	44	5	38
<i>Canthon</i> sp.	1	0	0	0	0
<i>Canthon chalcites</i>	10	2	9	3	12
<i>Cloeotus</i> sp.	0	0	1	1	4
<i>Deltochilum gibbosus</i>	32	39	45	31	18
<i>Geotrupes blackburnii</i>	6	6	9	4	2
<i>Glaphyrocantion viridis</i>	0	0	1	2	0
<i>Onthophagus hectate</i>	0	0	16	2	10
<i>O. orpheus</i>	0	1	2	10	4
<i>O. pennsylvanicus</i>	0	15	29	0	2
<i>O. striatulus</i>	4	1	3	0	1
<i>Phyllophaga</i> sp. 1	2	12	9	4	1
<i>P.</i> sp. 2	1	0	0	0	0
<i>P.</i> sp. 3	0	3	4	1	0
<i>Trichiotinus bibens</i>	0	0	0	1	0
<i>Trox</i> sp.	0	4	6	6	5
<i>T. monachus</i>	7	5	12	2	2
<i>T. punctatus</i>	2	0	1	0	1
<i>T. suberosus</i>	1	6	0	3	0
Unidentified	0	0	0	1	0
Total capture	67	135	191	76	100

of silphids were captured in the control plots. The control stands also had the lowest abundance, species richness and species diversity in captured Scarabaeidae and the highest measure for all 3 of these parameters was in the group selection cut plots. As expected, there were species-specific responses to the intensity of tree harvesting disturbance. In general, stand disturbance caused by tree harvesting increased the diversity and abundance of beetles within stands and this could still be measured 5 to 6 years following the tree harvests.

## ACKNOWLEDGMENTS

I thank Alex Mangini (USDA-Forest Service, Pineville, LA) for his assistance in getting the project started and showing me the treatment stands and Marco Miccozi helped with field collections during 1998.

Research support was provided through the project "Impact of Stand Management Practices on the Diversity of Beetles in the Ouachita and Ozark National Forests" dated August 1, 1999 to September 30, 2001 of Cooperative Agreement 33-CA-99-679. This research was supported in part by funds provided by the U.S. Department of Agriculture, Forest Service, Southern Research Station as part of their Ecosystem Management Research Program.

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